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Patient-Specific Foot Orthotics Effect on Lower Extremity Joint Loading for Rheumatoid Arthritis Patients using MRI-Based Musculoskeletal Models

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INTRODUCTION

Rheumatoid arthritis (RA) patients often have pain in the lower extremity, which in some cases can be caused by foot deformity and foot pain. With the intention to stabilize and align the foot patient-specific foot orthotics (FO) are often prescribed to this patient group. A limitation of the previous literature on FO to treat RA and related diseases is that it has focused exclusively on clinical outcomes of FO such as pain and physical function, while overlooking the biomechanical principles on which the rationales for FO is based [1].

The aim of this study was to investigate the effect of patient-specific FO on ankle, knee and hip loading during gait. This was accomplished by developing patient-specific (PS) musculoskeletal models (MS) capable of estimating joint mechanics with and without the FO.

METHODS

Four early stage RA patients were recruited for this study. A pair of FO was developed for each patient using a weight bearing casting technique. PS bone geometry was obtained from magnetic resonance imaging (MRI) images and segmented in an image analysis package (Mimics 19, Materialse, Belgium). Motion capture was performed with an eight-camera setup (Qualysis, Sweden) with reflective markers together with three force plates (AMTI, USA) sampling at 100 and 1000 Hz respectively. The gait trial consisted of two conditions: one with the PS FO and one with a control insole (C).

PS MS models of each patient were developed using the AnyBody Modeling System (AnyBody Technology, Denmark), Figure 1B. Muscle attachments were made PS based on the Twente Lower Extremity Model version 2.0 dataset using advanced morphing to customize a generic cadaver-based model with respect to PS morphology acquired from MRI [2].

Accurate joint centres and axes were calculated with analytical surface fits to the segmented MRI bones. Joint reference systems were defined based on the ISB recommendations.

RESULTS AND DISCUSSION

Resultant joint forces for the ankle, knee and hip joints are presented in (Figure 1) for the C and FO. The results showed that the ankle force is reduced with FO. Meanwhile, the resultant knee and hip joint forces increased with FO. Additional data from the model showed that, despite an increase in the total resultant forces in the knee and hip, change in the different joint moments and muscle forces still occur. These changes may potentially contribute to the reduction in pain. Further studies are needed to confirm this.

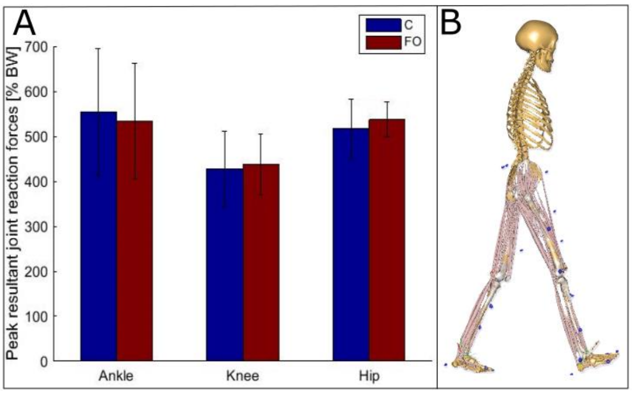

Figure 1: A: Mean peak resultant joint forces for the Ankle-, knee- and hip joint during the stance phase of gait with ± one standard deviation. B: Patient-specific AnyBody model

CONCLUSIONS

The results of this study indicate that FO can change the load distribution in the lower extremity. MS modeling is appealing for studying biomechanics due to the challenging nature of directly measuring the internal loading of the complex structure of the human body that occurs during motion. Further studies are needed to investigate if there is a relationship between changed loading in MS models and pain for RA patients.

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